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Ultrasound in the diagnosis and therapeutic management in undifferentiated shock patients in the emergency department

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ABSTRACT

Background: It is advised that circulatory failure be diagnosed and treated as soon as possible. We conducted a thorough analysis to assess POCUS's value in diagnosing shock in adult emergency department patients experiencing circulatory failure. *Method:* PubMed, Cochrane, Embase, and Google Scholar were the electronic databases we examined for publications published between 2018 and 2023. In addition to prospective and retrospective observational studies, we used data from randomized controlled trials reporting the POCUS diagnostic value in patients with shock in the emergency room. *Result:* In this systematic review, 761 patients from 7 papers were included. Research was carried out in Egypt, the United States, India, France, South Africa, and North America. With the exception of one research that was done in a general ward, all of the studies were carried out in emergency rooms. Multi-organ POCUS and TAPSE measurement are included in the ultrasound methodology. Clinical diagnosis, computed tomography angiography, and echocardiography conducted by cardiologists served as reference standards. *Conclusion:* POCUS has demonstrated high sensitivity and favorable likelihood ratio in identifying the etiology of shock, especially obstructive shock, in the studies included in this review.

Keywords: Ultrasound, therapeutic management, emergency department, shock, hypotension

1. INTRODUCTION

Early diagnosis and treatment of circulatory failure are recommended (Vincent and De-Backer, 2013). There are four forms of shock: distributive, cardiogenic, hypovolemic, and obstructive, and each requires a particular course of treatment (Vincent and De-Backer, 2013). Therefore, it's critical to determine the kind of shock the patient is suffering when they have circulatory failure. Clinically, shock

is distinguished from other conditions based on all available data, such as blood tests, medical history and imaging scans. Out of all of these, using an ultrasonography in particular has the ability to precisely define and pinpoint the cause of shock (Marbach et al., 2020; Vieillard et al., 2019).

Moreover, it is occasionally possible for many shocks to overlap, which complicates diagnosis (Vincent and De-Backer, 2013). Ultrasonography, which enables quick and direct image-based pathophysiological monitoring Díaz-Gómez et al., (2021), may therefore be essential for shock treatment. POCUS is the process for quick bedside identification of the cause of an acute disease using ultrasonography (Díaz-Gómez et al., 2021). It has gained a lot of attention recently (Mayo et al., 2017). Regarding POCUS for shock, several diagnostic procedures have been put forth (Perera et al., 2010). All procedures shared the qualitative evaluation of left and right ventricular size and contractile performance, as well as the physiologic assessment of pericardial fluid and tamponade, in the conventional cardiac view (Perera et al., 2010). Their early goal-directed ultrasonography diagnostic at the bedside was a typical characteristic.

In 2019, a systematic study was published on the diagnostic accuracy of POCUS for shock. The study, however, was restricted to a meta-analysis of just four observational ER studies. Furthermore, to the best of our knowledge, few comprehensive evaluation summarizing the diagnostic accuracy for each form of shock has been documented, despite the fast growth in literature dealing with POCUS in emergency and critical care settings (Mayo et al., 2017). Additionally, while the POCUS procedures for shock have delineated the results and approximate differentiation processes for shock Stickles et al., (2019), the precise sequence and location of ultrasound testing remain unclear. We carried up a comprehensive evaluation to evaluate the precision of POCUS in the diagnosis of shock in adult patients with circulatory failure in the emergency department.

2. METHOD

This study was conducted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021). In this study, the index test was defined as POCUS with echocardiography, which was done right away in shock patients to determine the etiology of circulatory failure. Regarding the location of POCUS, there were no limitations. Since there is no particular diagnostic technique for identifying the sock etiology, we used the medical data from each research as the reference standard to describe the clinical diagnosis. We searched electronic databases (PubMed, Cochrane, Embase, and Google scholar) for articles published in the period from 2018 to 2023.

We used keywords (intensive care, emergencies, critical illness, point of care, ultrasound, focus, echocardiography, hypotension, shock, and circulatory failure). We included secondary analyses of data from randomized controlled trials reporting the POCUS diagnostic value for the identification of etiology in adult patients with undifferentiated shock, as well as retrospective and prospective observational studies. This review's release date and language were both unrestricted. The aforementioned criteria were used by two researchers to evaluate each study separately for eligibility. Each abstract that satisfied the first set of requirements for inclusion was assessed as a full-text publication.

The publications that both extractors found fulfilled the eligibility criterion for full text review were included in the final data analysis. Any disagreements were settled by consensus, and where necessary, the relevant author was consulted. Data were independently gathered by four writers from the included papers. After completing their first training, the investigators gathered data and entered it into a pre-made data collecting form. The data collection form targeted; citation, country, sample size, design, number of patients, clinical setting, US protocol, reference standard, circulatory failure definition, US physician, main findings and conclusion.

3. RESULTS AND DISCUSSION

We included 7 articles in this systematic review with a total of 761 patients (Figure 1). Studies were conducted in Egypt, USA, India, France, South Africa and North America. All studies were conducted in emergency department except Zieleskiewicz et al., (2021) study which was conducted in General ward. Ultrasound protocol include, TAPSE measurement, and Multi-organ POCUS. Reference standards were Echocardiography performed by cardiologist, Computed tomography angiography and Clinical diagnosis (Table 1). Main findings of the included studies were presented in (Table 2). While the specific diagnosis of shock varied between the investigations, hypotension was consistently seen. All studies except one used the index test employed POCUS, or multiple-organ ultrasound, which includes echocardiography.

A clinical diagnosis based on medical records was specified as reference standard in nearly all research. In a PE patients, one study had previously suspected illness. Numerous comprehensive analyses have been carried out on the diagnostic precision of POCUS during emergency situations. For respiratory failure POCUS was shown to have a 0.092 sensitivity and 0.98 specificity in a systematic study (Yuan et al., 2021). A 2018 Cochrane systematic review that included 34 trials and more than 8 thousand patients for indicators identification of severe damage in thoraco-abdominal trauma reported 0.74 sensitivity and 0.96 specificity (Stengel et al., 2018). Depending on clinical evaluation, the challenge of determining the shock origin by POCUS may differ. Positive probability ratios and high specificity were observed in a prior systematic study, particularly in the case of obstructive shock (specificity 0.98 and positive likelihood ratio 40.5) (Stickles et al., 2019).

A different narrative analysis that looked at the diagnostic value for acute illnesses similarly revealed that pneumothorax, pericardial effusion, and right heart failure had exceptionally high specificity (Ding et al., 2011). Rahulkumar et al., (2019) study claims that the preliminary impression obtained from POCUS upon admission was equivalent to the medical diagnosis made during the hospital stay. In their investigation, the sensitivity for diagnosing obstructive and cardiogenic shock was good, while the sensitivity for the distributive group was poor. This could be because septic shock is dynamic and can present with a variety of complicated POCUS results (Ghane et al., 2015). In certain situations, repeated POCUS may be helpful in diagnosing septic shock. When many underlying mechanisms for shock are present, POCUS sensitivity is reduced once again.

According to a study by Ramadan et al., (2023), not all ultrasonography and echocardiography markers were useful for identifying distinct forms of shock. Aortic VTI and maximum IVC diameter were important distributive shock discriminators. Certain forms of shock were strongly associated with other measures, such as impaired left ventricular function in cardiogenic and mixed distributive cardiogenic shock, and pneumonia in distributive or mixed shock types. The POCUS group of patients had greater survival rates, a larger proportion of sufficient immediate diagnosis, and faster treatment than the traditionally treated group, according to the Zieleskiewicz et al., (2021) study. Landmark research that included 260 patients hospitalized to the intensive care unit due to severe respiratory failure demonstrated the potential diagnostic use of lung ultrasonography (Lichtenstein and Mezière, 2008).

Since then, it has been consistently demonstrated that POCUS is more effective than a chest X-ray with physical examination alone for diagnosing patients with acute respiratory failure (Pivetta et al., 2015; Silva et al., 2013). FOCUS is more sensitive for PE in patient groups with aberrant vital signs who are suspected of having PE, especially in those with an HR more than 110 beats/min, according to a research by Daley et al., (2019) For ED patients with aberrant vital signs, a quick bedside test that could reliably rule out PE or dramatically reduce its chance at the time the history and physical examination are completed might be very helpful.

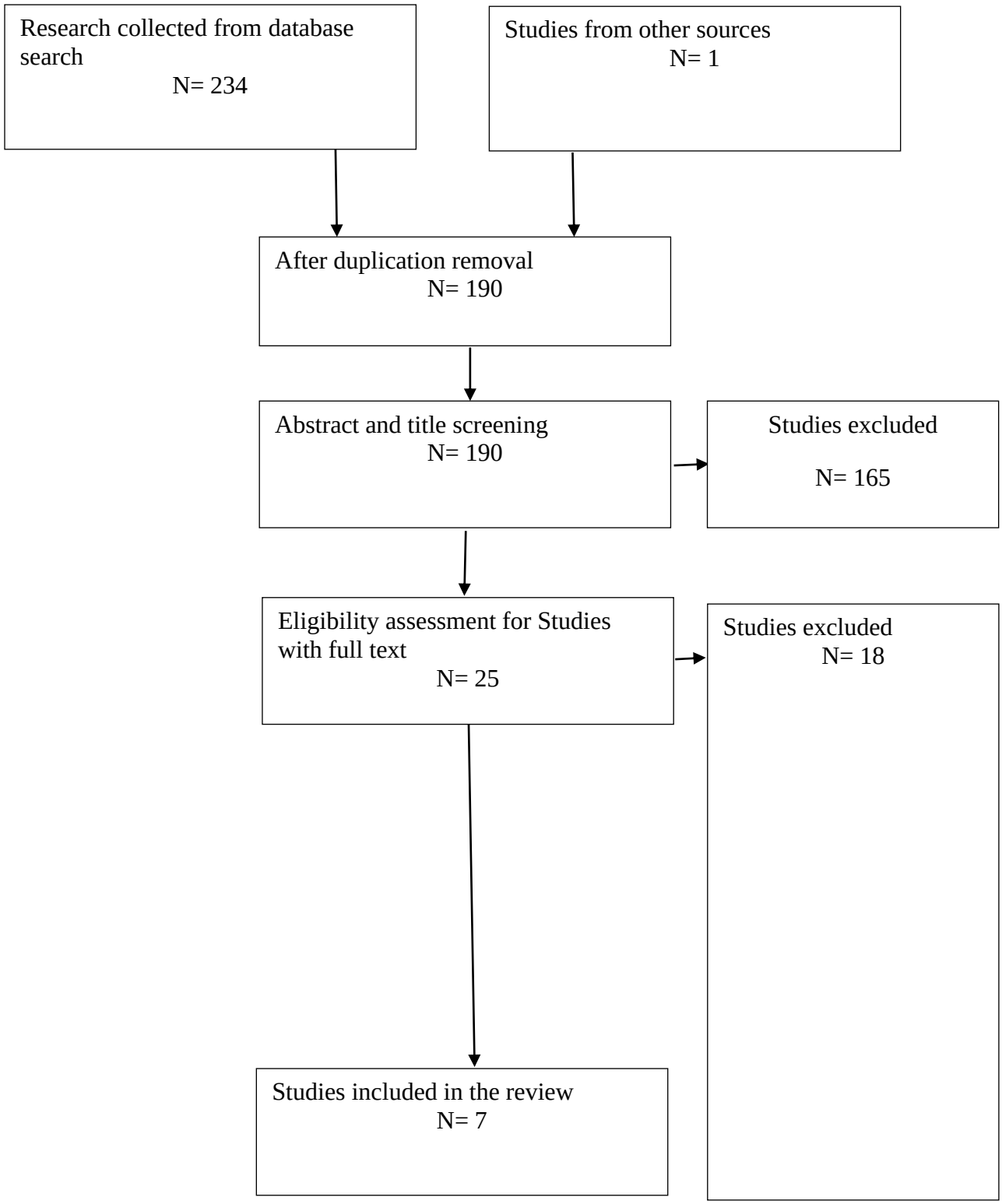

Figure 1 PRISMA consort chart of studies selection

Table 1 Characteristics of the include studies

Citation	Country	Sample size	Design, no. Of patients (location)	Clinical setting	US protocol	Reference standard	Definition of circulatory failure	US physician
(Ramadan et al., 2023)	Egypt	140	Cross sectional study	Emergency department	POCUS	Echocardiography performed by cardiologist	SBP less than 90 mmHg or a shock index of at least one, together with symptoms of tissue hypoperfusion such as changed mental status, reduced urine output, delayed capillary refill time, mottled skin, or increased lactate levels	Emergency physicians
(Daley et al., 2019)	USA	136	Prospective Cohort	Emergency department	TAPSE measurement	Computed tomography angiography	Hypotension or Tachycardia with suspected PE	Emergency physicians or trained medical students
(Rahulkumar et al., 2019)	India	97	Prospective Cohort	Emergency department	Multi-organ POCUS	Clinical diagnosis	shock index more than 1.0 and SBP less than 90 mmHg	Emergency physician
(Patil et al., 2020)	India	100	Prospective Cohort	Emergency department	Multi-organ POCUS	Clinical diagnosis after admission	Shock index more than 1.0 and SBP less than 90 mmHg	Emergency physician
(Keefer et al., 2021)	South Africa and North America	135	Prospective Cohort, six centers	Emergency department	Multi-organ POCUS	Clinical diagnosis by two clinicians	shock index more than 1 or SBP less than 100 mmHg	Emergency physicians trained to POCUS
(Zieleskiewicz et al., 2021)	France	83	Prospective Cohort	General ward	Multi-organ POCUS	Clinical diagnosis	MAP < 65 mmHg or HR < 40 bpm or HR > 120 bpm or UO < 50 ml/4 h	ICU physicians

(Elbaih et al., 2018)	Egypt	100	Prospective Cohort	Emergency department	Multi-organ POCUS	Clinical diagnosis	Unstable polytrauma patients	Unclear

Table 2 Main findings of studies included

Citation	Main findings
(Rahulkumar et al., 2019)	It took the point-of-care ultrasound 12 minutes on average to examine. It had a 0.860 Kappa index. This study emphasizes the use of POCUS in emergency medicine departments for the early detection of shock etiology. Point-of-care ultrasound diagnostic substantially agreed with medical diagnosis. With the exception of distributive shock, point-of-care ultrasonography demonstrated good effectiveness in accurately differentiating the shock etiology.
(Daley et al., 2019)	FOCUS demonstrated 64% specificity and 92% sensitivity for PE in all individuals. FOCUS was 100% sensitive and 63% specific for PE in the subgroup of 98 patients whose heart rates were greater than or equivalent to 110 beats per minute. For FOCUS, there was a good deal of interobserver agreement.
(Elbaih et al., 2018)	According to RUSH, hypovolemic shock is the most common diagnostic cause of unstability in polytrauma patients, followed by distributive, obstructive, and cardiogenic shock, in that order. When it came to diagnosing unstable polytrauma patients, RUSH had a 94.2% sensitivity rate and a 95.2% accuracy rate when it came to shock patients.
(Keefer et al., 2021)	For identifying cardiogenic shock, the presence of LVD on FOCUS exhibited a sensitivity of 62.5%, specificity of 94.1%, positive likelihood ratio of 11.6, negative likelihood ratio of 0.40, and accuracy of 90.3%. When evaluating otherwise undifferentiated hypotensive adult patients in the emergency room, the early detection of cardiogenic shock may be aided by the detection of left ventricular failure on FOCUS.
(Ramadan et al., 2023)	With an AUC of 0.888 and 0.772, respectively, the velocity time integral of the aorta and the IVC maximal diameter were effective discriminators for distributive shock. The ability to distinguish between distinct forms of shock was greatly aided by factors such as pneumonia, valve vegetations, pneumothorax, and left ventricular systolic function.
(Patil et al., 2020)	POCUS alone was shown to be accurate in 47% of patients and clinical assessment alone in 45% of patients, respectively, for diagnosis. However, the accuracy rose to 89% when the results of the clinical examination were combined with PoCUS. Distributive shock, which affects 38% of patients, was shown to be the most prevalent cause of shock, with sepsis being the most common subtype. Cohen's kappa coefficient = 1 was in full agreement with the combined clinical evaluation of patients with obstructive shock, whereas Cohen's kappa coefficient = 0717 was in considerable agreement with patients with distributive shock. The combined evaluation's total kappa correlation with PoCUS was 0.89, indicating nearly complete agreement with the final diagnosis.
(Zieleskiewicz et al., 2021)	The percentage of appropriate diagnoses, the time to start therapy, and maybe even the survival rate of ward patients experiencing acute respiratory or circulatory failure may all be improved by the systematic use of a portable POCUS equipment at the patient's bedside.

4. CONCLUSION

High sensitivity and a favorable likelihood ratio were observed in studies included in this review when using POCUS to identify the shock etiology, particularly obstructive shock. Therefore, these results have to be taken into account in further POCUS-based shock diagnosis procedures.

Ethical approval

Not applicable

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This study has not received any external funding.

Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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